DIGITAL VOLTMETER

Model 111

SIMPSON - DYNASCAN

INSTRUCTION MANUAL

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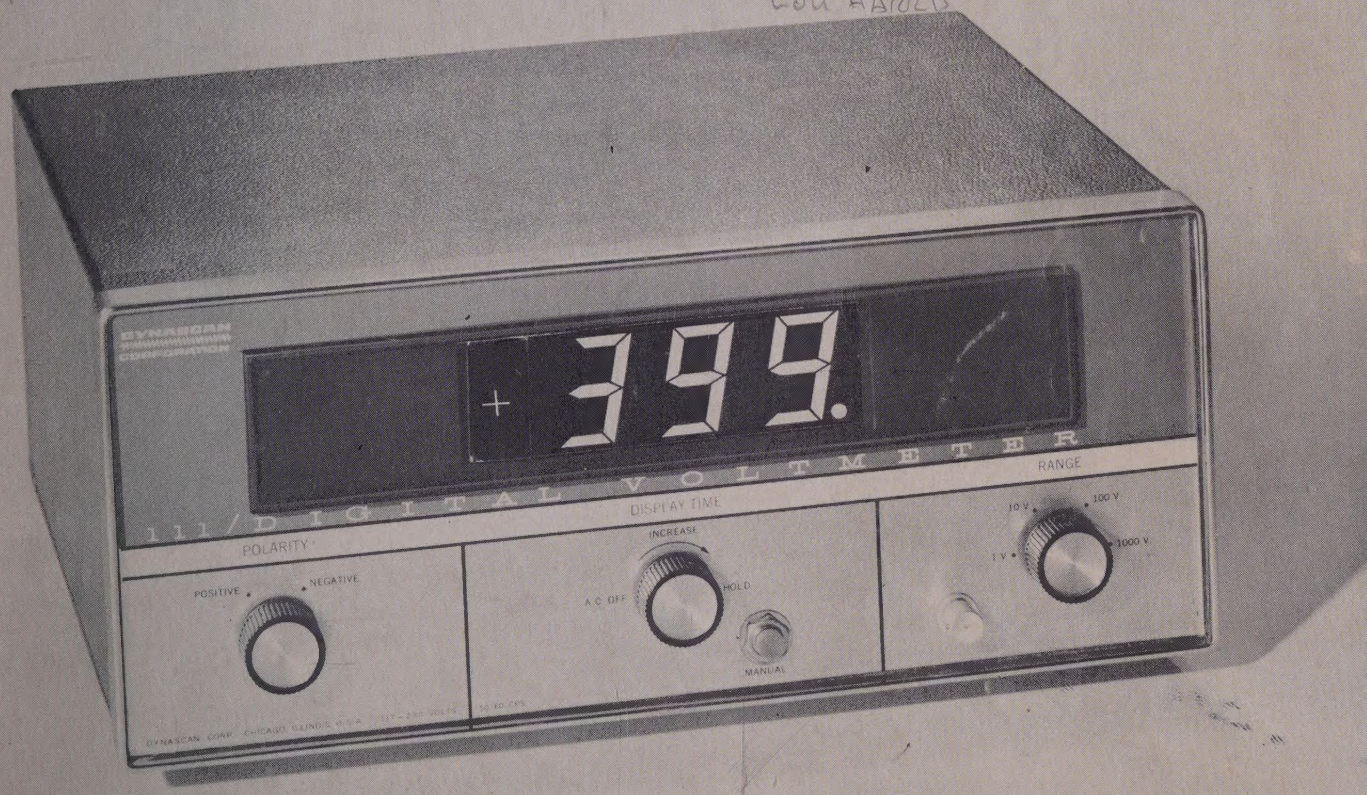

SIMPSON ELECTRIC CO.

DYNASCAN CORPORATION

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INSTRUCTION MANUAL

FOR

Model 111

Digital Voltmeter

DYNASCAN CORPORATION

1801 West Belle Plaine Avenue

Chicago 13, Illinois

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I. GENERAL SPECIFICATIONS

1.0 Introduction:

The Dynascan Model 111 Digital Voltmeter is a high input impedance instrument which will provide a three digit readout of any applied direct current voltage at its input terminals. Four decade ranges cover .001 to 999 volts with an accuracy of ±0.1% of reading, ±1 least significant digit. Other features are adjustable or manual Display Time control and automatic indication of improper polarity.

1.1 Specifications:

1.11 Input: 0 to 999 volts D.C. only (optional converter for A.C. measurements available).

1.12 Number of Digits in Readout: 3

1.13 Accuracy: ±0.1% of reading ±1 least significant digit.

1.14 Sensitivity: 1 millivolt lowest possible reading on the 1V Range.

1.15 Reference Voltage: Self-contained temperature compensated Zener diode.

1.16 Resolution: 1 Digit.

1.17 Balancing Time: Proportional to voltage being measured, maximum 1 second full scale.

1.18 Stability: Reaches accuracy after 15 min. warm-up at 25°C ambient.

1.19 Ambient Temperature: 0 to 40°C, (104°F) without forced cooling. With fan option 0 to 50°C (122°F).

1.20 Temperature Coefficient: A maximum error of ±.01% per degree C temperature difference from 25°C (77°F).

1.21 Ranges: 1 Volt (.000 to .999), 10 Volt (0.00 to 9.99) 100 Volt (00.0 to 99.9) and 1000 Volt (000. to 999.)

1.22 Over-Voltage Readout: Unit will scale continuously if voltage to be measured exceeds capability of range. Maximum input voltage without component failure is 50 volts on the 1V Range, 500 volts on the 10V Range, and 1000 volts on the 100V and 1000V Ranges.

1.23 Range Change: Manual from front of panel.

1.24 Decimal Point: Changes automatically with Range switch. Rear panel plug for external switching of Decimal Point when used with Model 125 AC-DC Converter.

1.25 Polarity: Selectable manually from front of panel. If incorrectly selected, instrument will read 000 and Change Sign light becomes illuminated indicating improper polarity.

1.26 Reverse Polarity Resolution: A minimum of 1% of full scale of reverse polarity causes Change Sign light to light.

1.27 Input Impedance: 11 megohms ±1% on all ranges except 1V Range where input is 1.1 megohm ±1%.

1.28 Input: Single ended, instrument's chassis ground is probe ground.

1.29 Readout: High brightness incandescent 7-Bar numerical display, 1-1/4" high.

1.30 Display Time: Continuously adjustable to 10 sec. A Hold position occurs at the end of the control.

1.31 Manual Recycle: A new reading may be initiated by depressing MANUAL button.

1.32 Controls:

Front of Panel:
- POLARITY plus (+) and minus (-).
- POWER On/Off and DISPLAY TIME control.
- MANUAL recycle button.
- RANGE switch.
- Probe input jack.

Back of Chassis:
- Decimal point socket for use with Model 125 AC-DC Converter.
- Accessory 110V plug.
- Fuse.

1.33 Primary Power Requirements: 117/234 volts, 50/60 cycle A.C., 30 watts.

1.34 Size: 5-1/4" High, 12-3/4" Wide, 13-1/2" Deep.

1.35 Weight: 17 lbs.

II. DESCRIPTION

2.0 Introduction:

The Dynascan Model 111 DVM is completely self-contained. It is normally delivered from the factory ready to operate from nominal 105/125 volts, 50/60 cps A.C. mains, but can also be operated from 210/250 volts, 50/60 cps A.C. mains by changing internal transformer connections in accordance with Fig. 3. Before placing the instrument into service, it is therefore adviseable to check which power lines will be used and if the higher voltage is chosen, to make certain that the 210/250V transformer connections have been made.

2.1 Accuracy and Resolution:

The rated accuracy of the Model 111 DVM is 0.1% of the reading, ±1 digit in the least significant figure in the readout. Thus the maximum error at the highest voltage which the instrument will read (999 volts) would be ±1.0 volts plus ±1 volt, or ±2 volts. Since at voltage readings which are less than full scale, the ±1 count becomes the most significant error, it is always desirable to read a voltage as close as possible to the full scale reading of the instrument.

2.2 Reference Voltage:

The accuracy of the instrument depends to a great extent on the stability of the reference voltage internal to the instrument. Since this fact is of importance, a highly stable temperature compensated Zener diode is used to develop the reference voltage against which all measurements are made. The instrument can be no more accurate than the stability and accuracy of the internal reference supply.

2.3 Balancing Time:

The balancing time of the Model 111 DVM is amount of time required for the instrument to read the applied voltage and display it in digital readout form. The maximum time required for balancing on any range is 1 second for full scale reading. For any other reading the balancing time in seconds is the fractional value of the full scale reading. Thus a reading of 39.5 volts requires .395 seconds for balancing.

2.4 Ranges:

The Model 111 DVM provides 4 Ranges: 0 - .999; 0 - 9.99; 0 - 99.9 and 999. volts D.C. at the accuracy, resolution and stability described above. Range change is by a manual switch from the front of the panel. The decimal point tracks with the Range switch such that the unit of measurement is always in Volts. Polarity is indicated from the front of the panel by illuminating an appropriate + or - sign which is the sense of the probe. If, accidentally, the probe is connected to the wrong polarity, then the word "SIGN" will appear below the polarity sign and the instrument will read 000 volts. Changing the polarity by means of the front panel switch will cause the proper sign to appear on the instrument panel and the unit to function properly.

2.5 Over-Voltage:

In the event that the measured voltage exceeds the range for which the Model 111 DVM has been set, the displays will flicker (continue to count) and never reach a reading. This is an indication that the voltage is in excess of the range selected. Adjustment of the Range switch to a higher range will correct this difficulty, and enable the instrument to read properly. The maximum Over-Voltage that the instrument is capble of handling is 50 volts on the 1V Range, 500 volts on the 10V Range and 1000 volts on the 100V and 1000V Ranges. Voltages in excess of these amounts can cause damage to the instrument.

2.6 Display Time:

The amount of time which a reading will be displayed is adjustable. The Display Time can be set from a fraction of a second to an indefinite period called HOLD. (Fully clockwise position of the Display Time control). When the instrument is set to operate in the HOLD mode, a new reading may be initiated by depressing the MANUAL button on the front of the panel. This MANUAL facility can be wired for remote operation so that readings may be taken from a distance.

2.7 Input Impedance and Input:

In order to make measurements and at the same time not load the circuitry under test, the Model 111 DVM has been designed with an 11 megohm input impedance on the three higher ranges, and a 1.1 meg input impedance on the 1V Range. The input is single ended and chassis is ground. Any time that measurements are made in a circuit where ground is not chassis ground, the instrument may be floated

to a potential not to exceed 250 volts. CAUTION: The 3-wire line connector has the safety connector connected to chassis ground. This must be disconnected for above ground measurements.

2.8 Input Probe:

A 100K ohm precision resistor is included in the probe to provide decoupling from the probe cable capacity for measurement of voltages in active circuits. This resistor is part of the instrument calibration. Replacement of this resistor with any other 100K ohm $\pm$0.5% resistor could result in a maximum error of 0.05% on the 1V Range and a negligible (.005%) error on the other Ranges. The 100K resistor is followed by the attenuator circuit and a .01 mfd shunt capacitor. The 100K and .01 form a 1 K.C. low pass filter which limits the effect of noise or signals in the circuit being tested on the Model 111.

2.9 Readout:

The digital display of the Model 111 DVM is a 7-Bar Display which can readily be read from distances up to 20 feet under conditions of high ambient illumination. The display numerals are composed of a number of individually lighted bars and are activated by 1-2-4-2 binary coded logic provided by the internal counters. The light bulbs are long-life telephone lamps type 24-A and are readily accessible for replacement by removal of the printed circuit card.

III. OPERATING INSTRUCTIONS

3.0 Introduction:

While the Model 111 DVM is generally regarded as being virtually "fool-proof" in its operation, and so designed that the performance will not suffer through the lack of knowledge of the operator, it will be found that better results will be obtained if a careful study is made of these Operating Instructions.

3.1 Description of the Controls:

Four operating controls appear on the front of the Model 111 DVM: The POLARITY switch, the DISPLAY TIME--A.C. OFF control, the MANUAL reset button and the RANGE switch.

3.11 Polarity Switch:

The Polarity switch determines the sense of the probe with respect to ground. When the Polarity switch is in the POSITIVE position the instrument will read correctly when the probe tip is connected to a positive source of voltage and the ground clip is connected to the minus source of voltage. Just the opposite is true when the Polarity switch is in the NEGATIVE position. When the Polarity knob indicates POSITIVE, a +(plus) sign will be illuminated at the left hand side of the display window showing that the probe is to be connected to positive polarity while the probe's associated clip should be connected to negative or ground. When the polarity is turned to NEGATIVE, a - (minus) sign shows, indicating that the probe should be connected to the negative polarity and the clip to the positive.

3.12 Display Time Control:

The center knob marked DISPLAY TIME also controls the A.C. power input. The instrument is OFF when the Display Time control is rotated fully counter clockwise. When the knob is advanced clockwise, the instrument is turned ON.

The Display Time knob also controls the amount of time that the voltage reading is displayed in the readout. With the knob turned to its maximum counter clockwise position, the display is held for the shortest amount of time. When the knob is turned fully clockwise to the HOLD position, the last reading will be displayed indefinitely. Intermediate display times can be achieved by adjusting the DISPLAY TIME knob between the maximum and the minimum positions.

3.13 Manual Button:

When the DISPLAY TIME control is in the HOLD position new readings may be taken at any time by merely depressing the MANUAL button on the front of the instrument. This function can be programmed remotely since it represents nothing more than a low voltage switch closure.

3.14 Range Switch:

The RANGE selector switch provides four positions of 1, 10, 100 and 1000 volt Ranges. Each number represents the full scale capability of that particular range. Actually the ranges are, 0 - .999; 0 - 9.99; 0 - 99.9 and 0 - 999. As the RANGE switch is rotated the decimal point moves so that the reading is always in volts.

3.15 Probe Input Connector:

The Probe Input Connector is located to the left of the RANGE selector knob. This is a standard BNC connector and mates with the connector provided on the end of the probe cable. This must be used with the instrument at all times in order to insure the maximum accuracy since the instrument is calibrated with the probe.

3.2 Making a Voltage Measurement:

Whenever making a voltage measurement the ground clip of the probe should be connected to chassis ground, and the probe tip to the source of voltage to be measured. When making these voltage readings you must remember that the instrument is capable of resolving very small changes in voltage approaching one part in a thousand. Variations in repeatitive readings on a power supply will indicate that the power supply voltage itself is actually changing and is not a result of an error in the Digital Voltmeter. There are very few ultra stable power supplies which will provide a continuous reading and it is this type of power supply which is used in the calibration of the instrument. At any time that voltage measurements are to be made where the ground clip is not connected to chassis ground, the instrument must be floated or insulated from the circuit being measured. It is also required that the circuit that is being measured be operated from an isolation line transformer since the chassis ground of the DVM is connected to power line ground by means of a third wire in the A.C. line cord. When floating an instrument to make this type of measurement, the instrument shall not be floated by more than 250 volts. Under these conditions it is extremely important that the operator be very careful in order not to expose himself to an electric shock. An additional hazard under voltage measurements of this type is that a high hum level may result producing inaccurate readings. This generally evidences itself by variations in the display voltage caused by the peak to peak A.C. voltage between probe and chassis of the Model 111.

3.3 Installation:

The Model 111 DVM has been calibrated at a temperature of 25°C (77°F). The instrument has a net temperature coefficient of ±.01% per degree C. Operation at elevated temperatures will introduce an error in accordance with this temperature

coefficient. The maximum recommended ambient temperature for operation of the Model 111 is 40°C (104°F). With the use of forced ventilation this can be extended to 50°C (125°F) ambient.

A Fan Accessory is available for the Model 111 DVM and will satisfy the requirements for operation to 50°C ambient. It is recommended that this fan option be employed whenever the instrument is to be used in a continuous duty operation, or where the instrument is to be included in a system involving rack and panel installation.

IV. SIMPLIFIED THEORY OF OPERATION

4.1 Theory of Operation:

The Model 111 DVM is basically a null-seeking balancing system. That is, the external voltage to be measured is compared to an internally generated voltage of opposite polarity which is adjusted electronically to balance the input voltage by sensing "0" volts at a summing point of the two. In order to provide numeric readout, the internally generated voltage is divided into 1,000 discreet steps starting from "0" volts and increasing up to some fixed value dependent upon the unit's calibration. Each step corresponds to a number between 000 and 999 and the number for which balance occurs is corrected for in terms of the input voltage.

Fig. 2 is a simplified block diagram of the Model 111 DVM. The three stages of decade counters provide the 1,000 possible output states of 000 to 999. A 7-Bar display is connected to each of the decades to provide the readout of the 1-2-4-2 logic in each of the counters. The counters also drive the Digital to Analog Converter which divides a reference voltage into 1,000 steps starting with "0" volts output in the count of 000 and approximately 5 volts output for the count of 999. As the counter scales from 000 to 999 the output of the D to A Converter consists of a staircase waveform where each additional pulse added to the counter causes the D to A Converter output to increase by 1/1000 of the reference voltage. Since the Model 111 DVM requires no more than 1 sec. to achieve balance the basic pulse repetition frequency at the input to the counters is therefore 1 K.C. This frequency is thus the clock rate of the instrument.

The Polarity switch reverses the output sense of the D to A Converter, that is, in measuring a positive voltage a negative going staircase is generated. Conversely a positive staircase is generated when negative voltages are to be measured.

Assume now that a positive input voltage is applied between the probe and ground. The input signal is first attenuated by the Range switch and appears as some voltage E-1 applied to the summing network consisting of R-1 and R-2. The other signal applied to the summing network is the D to A Converter output E-2.

Assume that initially the counters are in the 000 state. This may be accomplished by pushing the Manual Recycle. If the instrument is in the automatic mode then at some time dependent upon the setting of the Display Time control the counters will be automatically reset. When the counters read 000 the output of the D to A Converter, E-2, is "0" volts. Thus a positive signal representing an out of balance signal appears at the summing point. The operation is now divided into two 1/2 cycles of the clock period. During the first 1/2 cycle (approximately 500 microseconds) the input and output switches on either side of the amplifier are closed. The amplifier has "0" volts at its input since the summing point is shorted to ground during this interval. Furthermore, the output is shorted to ground thus no signal passes to the counters and the input and output capacitors charge to their steady state values. During the second 1/2 cycle of the clock period the switches are opened. The positive out of balance signal is then amplified and appears at the output of the amplifier as a positive going pulse. The series diode passes this pulse to the counters causing a count of 001 to appear. This then causes the output of the D to A Converter to go to a negative voltage of 1/1000 of the reference voltage, which completes the action of the first clock period.

The process is duplicated again in the second clock period. During the first 1/2 cycle the switches are closed to establish "0" volt reference. In the second 1/2 cycle they are opened and a positive out of balance condition at the summing point will initiate another count and the instrument will try again for balance.

If the voltage to be measured is in range then at some count between 000 and 999 a "0" or slightly negative voltage will be obtained at the summing point. At this time no more pulses can pass to the counters through the series diode and the instrument reaches equilibrium.

At equilibrium the Display Time Generator starts its function and displays the final state of the counter for a time dependent upon the setting of the Display Time control and/or the Manual Recycle button. It also (not shown in Simplified Block Diagram) locks out pulses from the amplifier so that stray noise spikes or removal of probe will not cause spurious readings. At the end of the display cycle the counters are reset and the instrument repeats the cycle just described.

In the case of a wrong polarity input signal a negative going pulse will appear at the output of the amplifier during the second 1/2 cycle of the first sampling period (counters=000). The series diode to the counters prevents them from counting, however, the other diode passes the negative pulse and triggers the change sign flip-flop. This lights the Sign lamp. Reversing the Polarity switch reverses the sense of the D to A Converter output and the sense of the amplifier output so that a negative out of balance signal at the summing point will initiate a count and each count will produce a positive step at the D to A Converter output.

4.2 Physical Construction:

The Model 111 DVM is divided internally into seven modules. Those modules not affecting calibration are:

The three counter boards each of which contains a 7-Bar readout. Fig. 5.

The power supply board, Fig. 6, and the control board which contains the $\pm$ and Sign indications. Fig. 7.

The other two modules are the D to A Converter which contains the Polarity switch Fig. 8, and the amplifier Fig. 9 which contains the Zener reference input attenuator Fig. 10, chopper assembly Fig. 11, and offset adjustment Fig. 12.

V. CALIBRATION PROCEDURE

5.1 Applicability:

This procedure presumes that the only observable change in the performance of the instrument has been a constant percentage error over any voltage range in both polarities or a constant magnitude error. (i.e. 1 or 2 counts) on the 1V or the 1 and 10V Ranges in one polarity only. The constant percentage error is herein termed a calibration error and the constant magnitude is termed an offset error.

If a Model 111 exhibits a non-linear error, (i.e. the percentage error is not constant) it is due to a component failure and the following procedure will not remedy the performance.

5.2 Required Equipment:

The correction of an offset error requires an oscilloscope which will display a 1/2 volt 1 K.C. square wave. The scope should have amplitude calibration. The correction of a calibration error requires an oscilloscope and a test voltage.

The calibration test voltage may be obtained from a precision calibrated voltage supply or from a stable supply and a precision voltmeter. In either case the equipment should satisfy the following general requirements:

Voltage Accuracy: At least .02% preferably .01%.

Voltage Stability: Short time stability of at least .005%.

Voltage Source Impedance: Less than 100 ohm for 1V Range. Less than 1,000 ohm for 10V, 100V and 1000V Ranges.

Voltage Polarity: The source polarity should be reversing without introducing excessive power frequency noise as stipulated below.

Voltage Source Noise: Less than 100 microvolts peak to peak of noise in the spectrum 0 to 1000 cps for calibration of 1V Range. Less than 1 millivolt, etc, for 10V Range. Less than 10 millivolt, etc. for 100V Range. Less than 100 millivolt,etc, for 1000V Range. Above 1 K.C. and RC filter on the input of the Model 111 attenuates noise 6 db/octave.

Voltage Amplitude: One voltage is required for each Range and in order to obtain maximum accuracy of calibration this voltage should be close to maximum for the particular Range. 0.950, 9.50, 95.0 and 950. are the recommended test voltages.

A Phillips screwdriver with an insulated shaft should be used to make the calibration adjustment.

5.3 Before Starting:

The D.C. voltage test points given elsewhere in this manual should be tested prior to the following procedure.

An offset check and re-adjustment should be made prior to a calibration check even though the instrument performance had not indicated an offset error.

5.4 Offset Adjustment Procedure:

1. Remove Model 111 case.
2. Remove Amplifier Service Shield (extreme right or input side).
3. Connect oscilloscope vertical input to red, white and blue wire terminal. See Fig. 13.
4. Connect oscilloscope ground to Model 111 chassis.
5. Connect oscilloscope external sync to 220 ohm resistor on Control Board. See Fig. 14.
6. Connect Model 111 to power line (118 volt) and switch ON.
7. Allow 5 minute warmup.
8. Rotate DISPLAY TIME knob full clockwise, i.e. to "HOLD".
9. Short probe tip to probe clip.
10. Switch Range switch to 1V.

11. Press RESET button to obtain a .000 display. If .001 or .002 is displayed, change the POLARITY switch setting and press RESET again. A .000 display should be observed at this time.

12. Adjust oscilloscope to display the signal. A typical signal is given in Fig. 18. (External Sync.)

13. Compare the A portion of the signal with the B portion. The voltage difference of A & B is termed "Offset". An optimum or zero offset signal is shown in Fig. 19. Measure with scope the magnitude and sign of B with respect to A.

14. Change the POLARITY switch setting and measure magnitude and sign of offset again.

15. Compare the results of Steps 13 & 14. The offset should be less than 0.2 volts in both polarities. If the offset is greater than 0.2 volts and of opposite sign, see Fig. 20, the offset can be minimized by adjustment of R-307 on BT-88; see Fig. 15. Rotate R-307 until the offset is zero or of equal magnitude and sign for both positions of the POLARITY switch. An offset of less than 0.2 volts should result from this adjustment. If the result is appreciably greater than 0.2 volts a component failure is probable and the unit should be serviced by factory trained personnel. If the offset is less than 0.2 volts, proceed with calibration.

5.5 1V Calibration:

1. Perform Steps 1 thru 8 of Offset Adjustment Procedure.

2. Connect probe to +0.950 test voltage source.

3. Switch RANGE switch to 1V.

4. Switch POLARITY switch to POSITIVE.

5. Adjust the DISPLAY TIME control to a convenient display time. If the display does not read .950 on any cycle, adjust the 1V calibrate potentiometer in amplifier housing until a .950 display is obtained. Advance the DISPLAY TIME knob to hold on the .950 display.

6. Adjust the oscilloscope to display the balance condition. Note the magnitude and sign of the unbalance. See Fig. 21 for typical balance waveforms and unbalance measurement.

7. Change Model 111 POLARITY switch from POSITIVE to NEGATIVE and reverse the polarity of the test voltage source. The display should hold on .950 during this switching.

8. Note the magnitude and sign of the unbalance. If the sign of the unbalance is the same for both positions of the POLARITY switch the balance can be improved by adjustment of the 1V calibrate pot, See Fig. 15. Adjust this pot for minimum unbalance in one polarity; switch polarity; check balance and re-adjust pot if necessary. Final unbalance should be less than 0.3 volts in either polarity.

5.6 10V Calibration:

Repeat the procedure given in paragraph 5.5. Use 9.50 as a test voltage and adjust the pot marked 10V.

5.7 100V Calibration:

Repeat the procedure given in paragraph 5.5. Use 95.0 volts as a test voltage and adjust the pot marked 100V.

Note:- This calibration must follow the 10V calibration and must be performed after any adjustment of the 10V pot because of the interaction of these adjustments, see Fig. 10.

5.8 1000V Calibration:

Repeat the procedure given in paragraph 5.5. Use 950. volts as a test voltage and adjust the pot marked 1000V.

Note: - This calibration must follow the 100V calibration and must be performed after any adjustment of the 10V or 100V pot because of interaction of these adjustments.

5.9 Linearity Check:

In the paragraph on applicability of the calibration procedure a linearity check was implicitly suggested. The performance of this test can be made with a stable 10V supply and a decade voltage divider with .2% or better accuracy. Greater accuracy is not necessary where the intent is only to determine whether a component has failed. A component failure would result in a gross error. It is sufficient to check the linearity on the 1V and/or 10V Range, but both polarities of input should be checked. This completes instrument calibration.

VI. MAINTENANCE

6.0 WARNING:

CARE MUST BE EXERCISED WHEN MAKING MEASUREMENTS AT CONNECTORS SINCE ACCIDENTAL SHORTS MAY CAUSE COMPONENT FAILURE.

6.1 Lamp Replacement:

6.11 Test Equipment: The following test equipment is required:

(1) 20,000 ohm per volt D.C. voltmeter
(2) 1.5 volt D.C. source; battery or line isolated supply.

6.12 D.C.Voltages:

In general, the D.C. voltages to the lamps will be present. However, it is preferable to ascertain this before undertaking a lamp replacement. For each counter board both V_{LF} and V_L must be present. See Fig. 4. V_{LF} supplies power to the C & D lamps, and V_L supplies the remaining lamps including the decimal point lamp. Hence, if either the C or D bar lights up and if one of the remaining bar lamps also functions, V_{LF} and V_L can be assumed to be present. The plus and minus indicators, the sign lamp and the decimal point for the 1V Range, are powered by V_c and if the unit functions correctly this voltage can be assumed to be correct.

6.13 7-Bar Display Lamps:

Turn the Range switch to the 1V Range and connect the D.C. source with the correct polarity to the input probe. The Model 111 display should now flicker continuously since an over-voltage has been applied. Locate the bulb or bulbs which do not light. Refer to Fig. 4; this drawing gives the lamp designations and their counter board test points. Connect the positive lead of the D.C. voltmeter to V_G. See Fig. 16. Connect the negative lead to the test point associated with the suspected lamp. If the meter reads 0.6 volts, the lamp should be replaced. If the meter reads 20 volts, the counter circuit is defective and should be returned for service.

6.14 Decimal Point and Plus-Minus Lamps:

These lamps are manually switched and may be checked by measuring the voltage between V_G and the appropriate connector terminal. See the connector wiring diagram, Fig. 17.
For example, if the decimal point lamp is out when the Range switch is on 1000V, and the voltage between pin V on Connector II and V_G is zero, the lamp is open. If the voltage is 20 volts, the harness or switch is open.

6.15 Sign Lamp:

This lamp is switched by a transistor and the circuit is not readily reached by test probes. If it fails to light when an incorrect polarity voltage is applied to the probe, the lamp should be replaced by a known good lamp. If after replacement the lamp still fails to light, the control board requires service.

6.16 Lamp Replacement:

GE #1764-D 28 VOLT OPERA AT 20V

Burned out bulbs should be replaced by type ~~24-A telephone lamps only~~. Failure to use this bulb may cause premature burn out or circuit damage.

6.2 D.C. Voltage Checks:

6.21 Test Equipment:

The Model 111 contains two basic power supplies. One is a regulated supply to power the reference and low level signal circuits located on the amplifier chassis. The second is an unregulated supply which powers the counters and control circuitry. A check of both of these supplies must be made before any malfunctions can be localized. In general, there are two types of measurements, one being a measurement of voltage the other being a measurement of ripple. The following equipment is required:

(1) 20,000 ohms per volt of known calibration
(2) Scope or peak detector capable of resolving 100 MV peak to peak.

6.22 Unregulated Supply:

All voltages are measured with respect to V_G, located on the power supply board. See Fig. 16.

(1) Measure V_B on control board, see Fig. 14. V_B should be $+11 \pm .8V$ with no greater than a 100 millivolt ripple peak to peak.

(2) Measure V_C on control board, see Fig. 14. V_C It should be - 1.75 to - 1.85 times the value of V_B. That is, if V_B is + 11.0 then V_C will be -19.2 to -20.4 volts. The ripple should be no more than 100 millivolts peak to peak.

(3) Measure V_{LF} at output of power supply pin N connector VI, see connector wiring diagram Fig. 17. This should be between -19 and -23 volts. This voltage is not critical since it only supplies power to the C & D lamps.

(4) Measure V_L at output of power supply Pin N connector VI, see connector wiring diagram Fig. 17. This should be between 17 and 19 volts and is also not critical since it supplies the remaining lamps on the counter boards. Further, it is a full wave rectified D.C. source without filtering, see power supply schematic Fig. 6.

Voltages out of range indicate a defective power supply, see Fig.6. High voltages together with high ripple indicate a defective transistor. Low voltages with high ripples generally indicate defective filter capacitors particularly C-205 and C-203. Correct voltages with high ripples generally indicate defective capacitors in the bases of the dynamic filters, namely C-204, C-201 and C-202.

6.23 Regulated Supply:

All voltages are measured with respect to "0" volts located at pin C of connector I, see connector wiring diagram Fig. 17.

(1) Measure +6V, pin A of connector. This should be 5.7 to 6.7 volts. An out of range voltage generally indicates a defective nuvistor. This tube must be good before making further measurements.

(2) Measure +60V at pin B connector I. This should be between +75 and +95V. This voltage supplies plate voltage to the nuvistor and its actual value is not critical, greater than +55 volts being sufficient for normal operation.

(3) Measure -20V at pin L connector. This is the regulated supply and should be -20V $\pm$.3V at a 117V line. If it is not, the unit is defective and should be returned for service. Since this supply is directly related to the calibration and accuracy of the instrument, only laboratories equipped for calibration should attempt the repair.

6.3 Localizing Trouble:

6.31 If the Model 111 does not function properly, the trouble should be isolated to a particular board. This is advantageous since five of the boards may be changed without affecting calibration. These five are the three counters, the control and power supply boards.

6.32 Power Supply: Voltage measurements as outlined in Section 6.2.

6.33 Harness Check:

Verify that all solder connections are good and clean connector edge of board with solvent. Locate and verify that all D.C. voltages are available at the connectors. Note: - Do not short power connections as permanent damage to transistors may result.

6.34 Localizing Charts:

If Steps 6.32 and 6.33 fail to yield a working unit, then use the following test programs to locate the trouble. Each of the programs contains a list of test conditions and/or procedures to follow through the program. For example, Test conditions I state that measurements must be taken during the first 10 seconds of warmup after the unit has been off for at least one minute. Hence, when test conditions I are listed in the chart, the unit must be allowed to cool for one minute and measurements must be taken in the first ten seconds.

6.35 Test Conditions:

Test Conditions I Remove plug from line. Short probe.
Set Display Time to "Hold".
Let unit cool for one minute.

Test Conditions II Set Display to "Hold". Preset to 000 by depressing MANUAL RESET during first 10 second interval. Polarity switch to "Positive" (Negative). A "Positive" (Negative)3V source connected to input. Short D to A output to chassis, see Fig. 13. Allow one minute warmup.

For points of measurement, refer to connector wiring diagram Fig. 17.

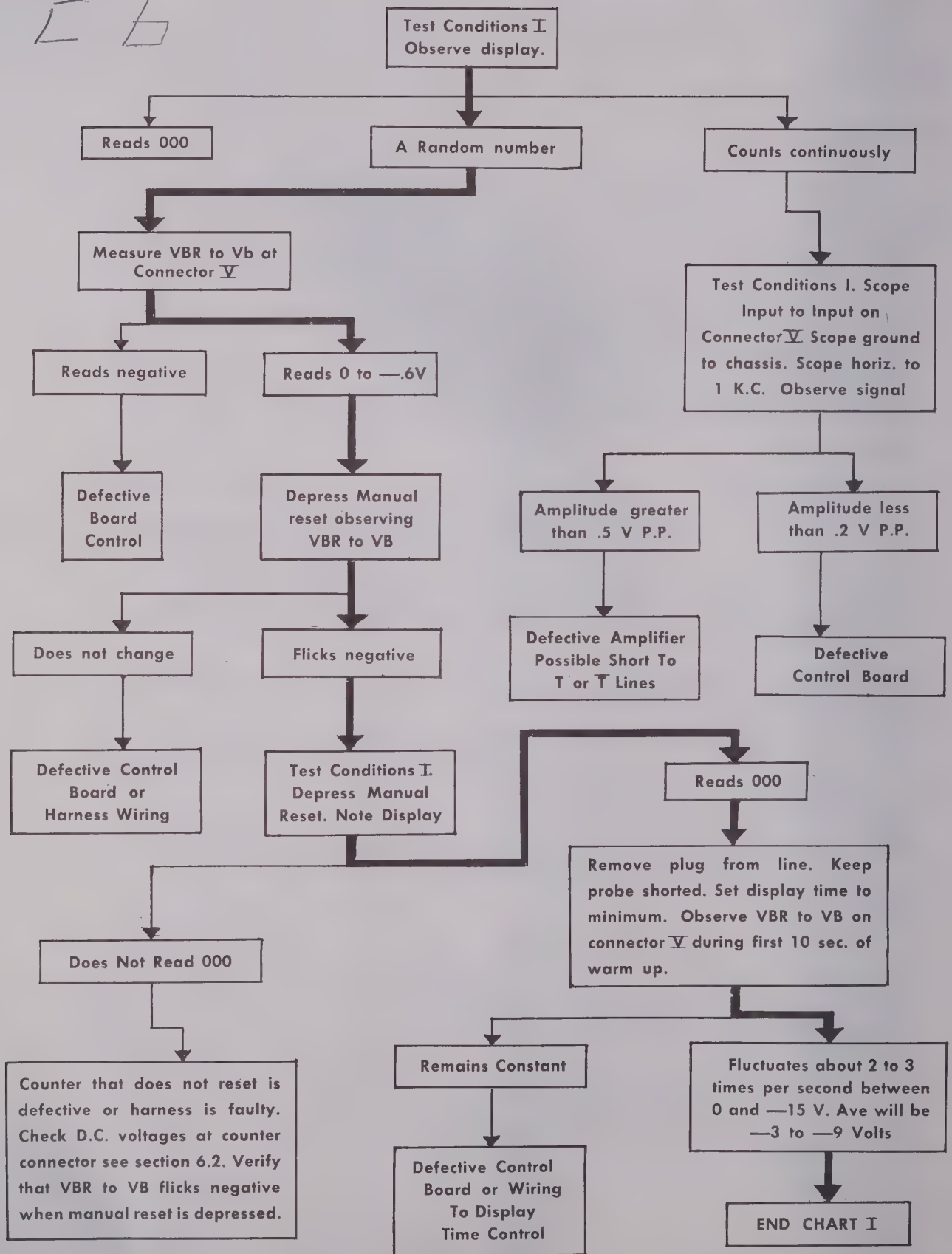
6.38 If the Model 111 passes all of the tests in the localizing charts then only the following malfunctions can occur.

(1) The unit will not correctly indicate a reverse polarity input. This may be tested by putting in a reverse polarity D.C. voltage of 1% of the range setting. A failure indicates either a burned out bulb or defective control board.

(2) The unit counts but will not display a reading. This is indicative of a defective control board.

(3) Unit reads a voltage but it is out of calibration. In this case, there are three types of errors. The first of these is a constant number of digits or offset error. This error if less than 4 digits may be corrected by offset adjustment (see Calibration Procedure) and in general will be most noticeable on the 1V Range. The second type of error is a constant percentage error. This is a true calibration error and may be corrected by re-calibration. The last type of error is a discontinuity in the linearity of the instrument. This error may be detected with a stable supply of 1 or 10 volts and a 0.1% decade divider. Any discontinuity which results in the unit being out of calibration by 2 counts or more indicates a defective D to A Converter board.

6.36 Localizing Chart I:


Test Conditions I. Observe display.
Reads 000
A Random number
Counts continuously
Measure VBR to Vb at Connector V
Reads negative
Reads 0 to —.6V
Defective Board Control
Depress Manual reset observing VBR to VB
Does not change
Flicks negative
Defective Control Board or Harness Wiring
Test Conditions I. Depress Manual Reset. Note Display
Does Not Read 000
Counter that does not reset is defective or harness is faulty. Check D.C. voltages at counter connector see section 6.2. Verify that VBR to VB flicks negative when manual reset is depressed.
Test Conditions I. Scope Input to Input on Connector V Scope ground to chassis. Scope horiz. to 1 K.C. Observe signal
Amplitude greater than .5 V P.P.
Amplitude less than .2 V P.P.
Defective Amplifier Possible Short To T or T Lines
Defective Control Board
Reads 000
Remove plug from line. Keep probe shorted. Set display time to minimum. Observe VBR to VB on connector V during first 10 sec. of warm up.
Remains Constant
Defective Control Board or Wiring To Display Time Control
Fluctuates about 2 to 3 times per second between 0 and —15 V. Ave will be —3 to —9 Volts
END CHART I

6.37 Localizing Chart III:

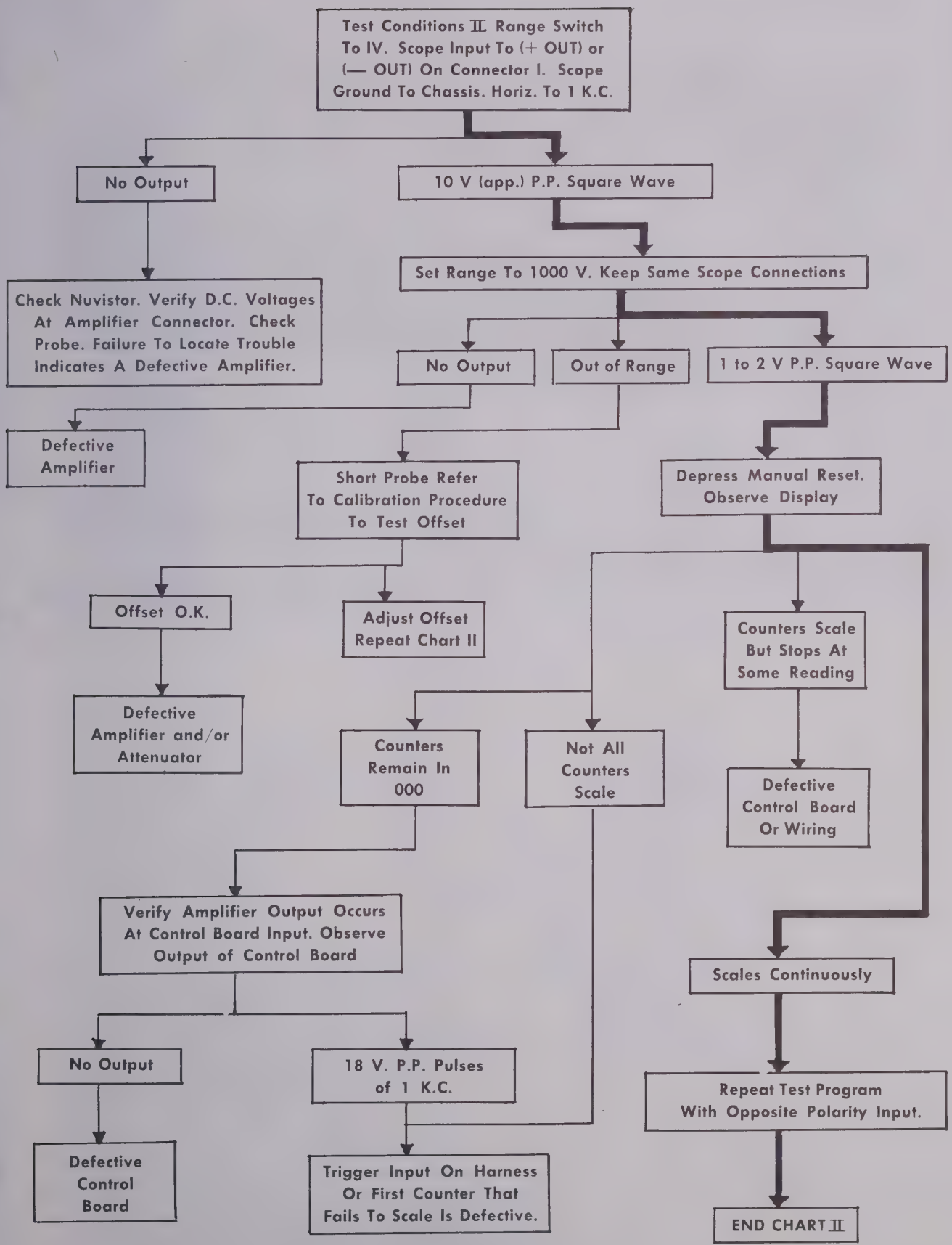

Test Conditions III. Range Switch To IV. Scope Input To (+ OUT) or (— OUT) On Connector I. Scope Ground To Chassis. Horiz. To 1 K.C.
No Output
10 V (app.) P.P. Square Wave
Check Nuvistor. Verify D.C. Voltages At Amplifier Connector. Check Probe. Failure To Locate Trouble Indicates A Defective Amplifier.
Set Range To 1000 V. Keep Same Scope Connections
No Output
Out of Range
1 to 2 V P.P. Square Wave
Defective Amplifier
Short Probe Refer To Calibration Procedure To Test Offset
Depress Manual Reset. Observe Display
Offset O.K.
Adjust Offset Repeat Chart II
Counters Scale But Stops At Some Reading
Defective Amplifier and/or Attenuator
Counters Remain In 000
Not All Counters Scale
Defective Control Board Or Wiring
Verify Amplifier Output Occurs At Control Board Input. Observe Output of Control Board
Scales Continuously
No Output
18 V. P.P. Pulses of 1 K.C.
Repeat Test Program With Opposite Polarity Input.
Defective Control Board
Trigger Input On Harness Or First Counter That Fails To Scale Is Defective.
END CHART III

Fig. 1 — Dynascan Digital Voltmeter

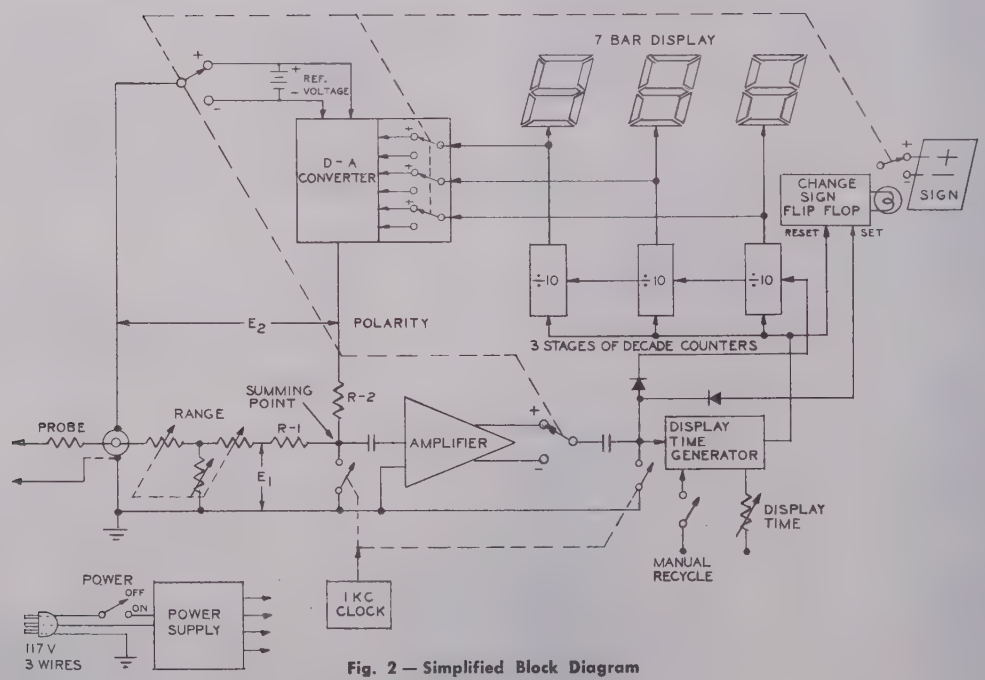


Fig. 2 — Simplified Block Diagram

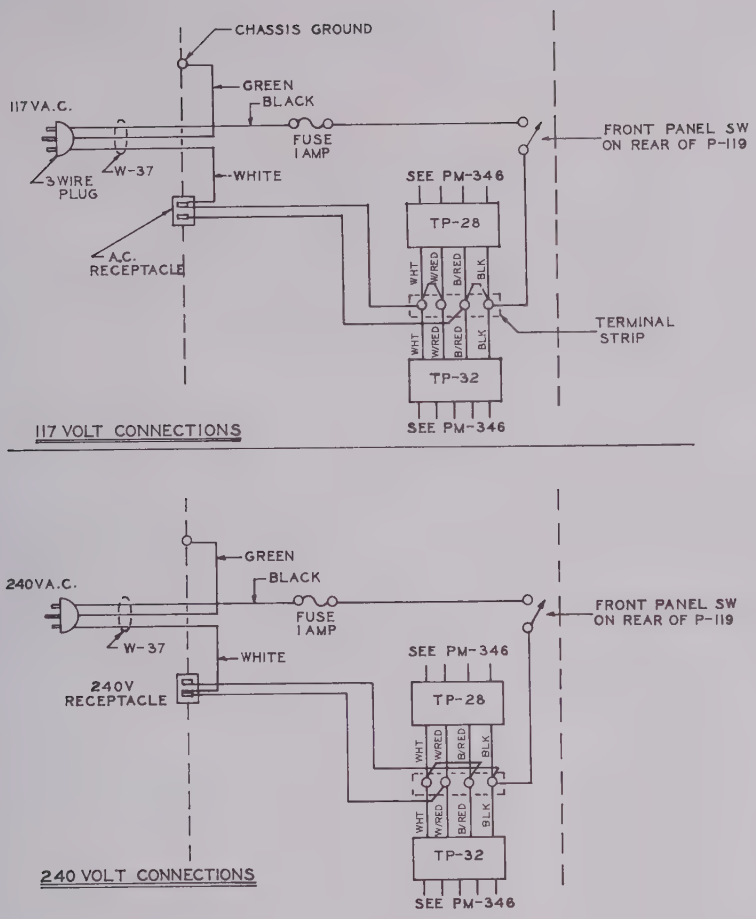
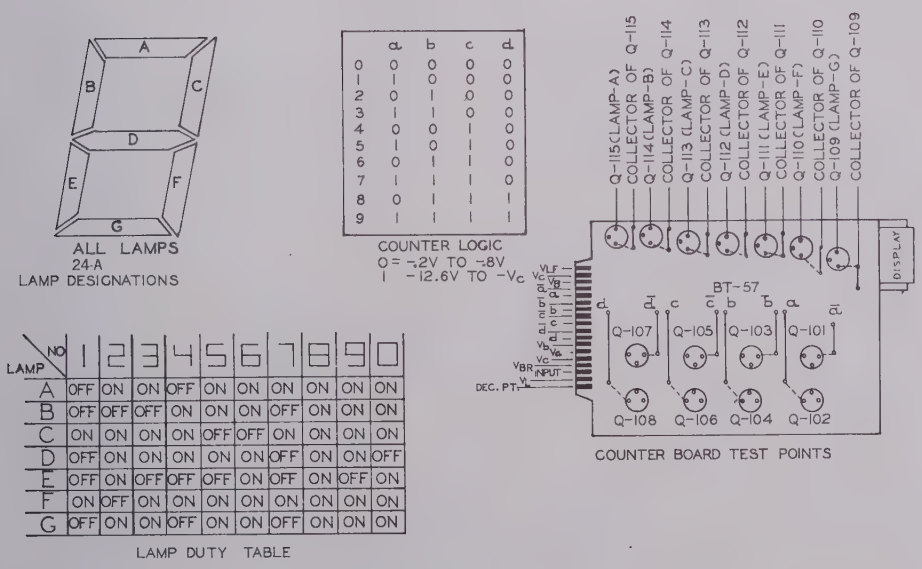


Fig. 3 — 117V & 240V A.C. Power Wiring Diagram



LAMP \ NO	1	2	3	4	5	6	7	8	9	0
A	OFF	ON	ON	OFF	ON	ON	ON	ON	ON	ON
B	OFF	OFF	OFF	ON	ON	ON	OFF	ON	ON	ON
C	ON	ON	ON	ON	OFF	OFF	ON	ON	ON	ON
D	OFF	ON	ON	ON	ON	ON	OFF	ON	ON	OFF
E	OFF	ON	OFF	OFF	OFF	ON	OFF	ON	OFF	ON
F	ON	OFF	ON	ON	ON	ON	ON	ON	ON	ON
G	OFF	ON	ON	OFF	ON	ON	OFF	ON	ON	ON

LAMP DUTY TABLE

Fig. 4 — Counter Test Points

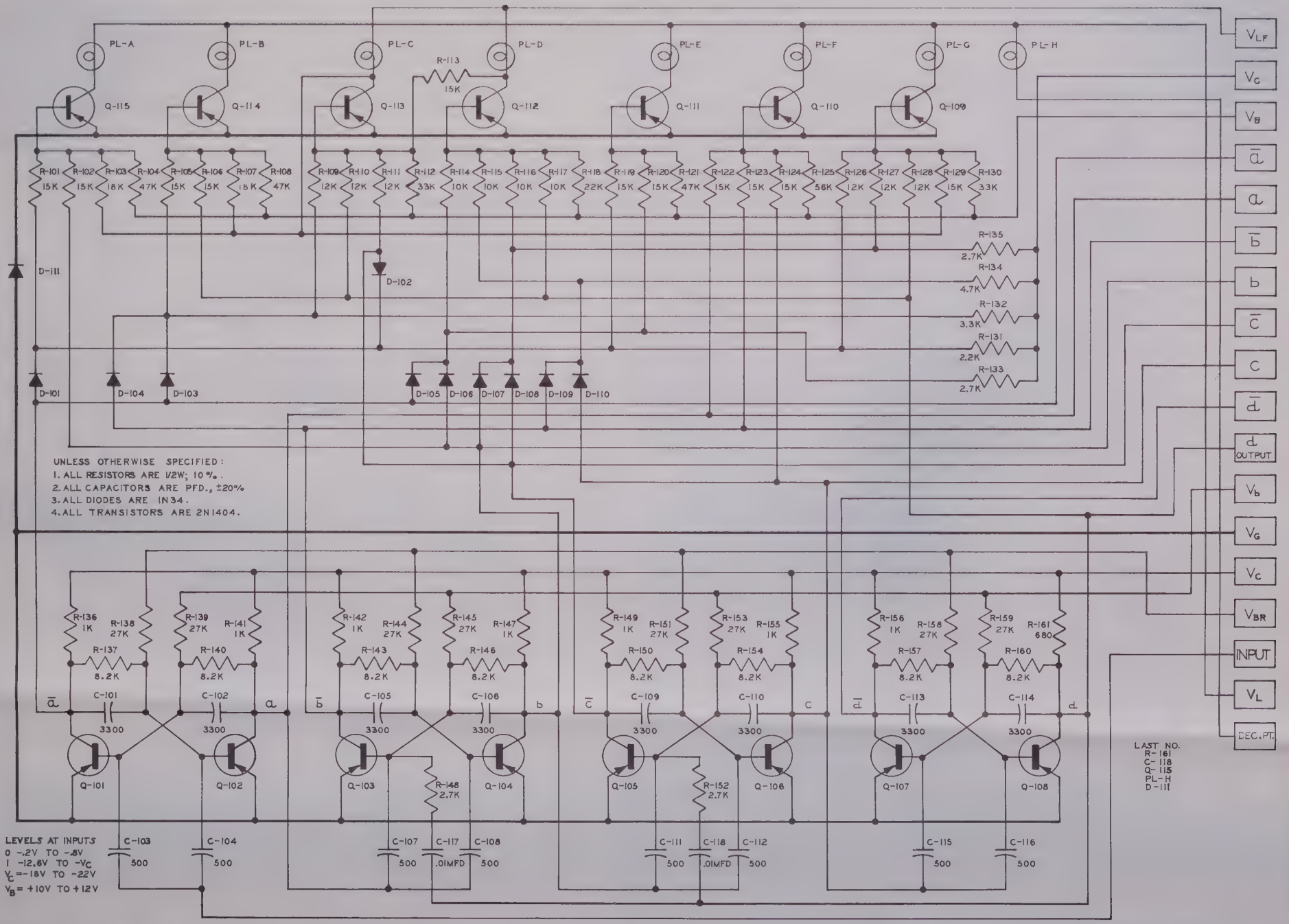
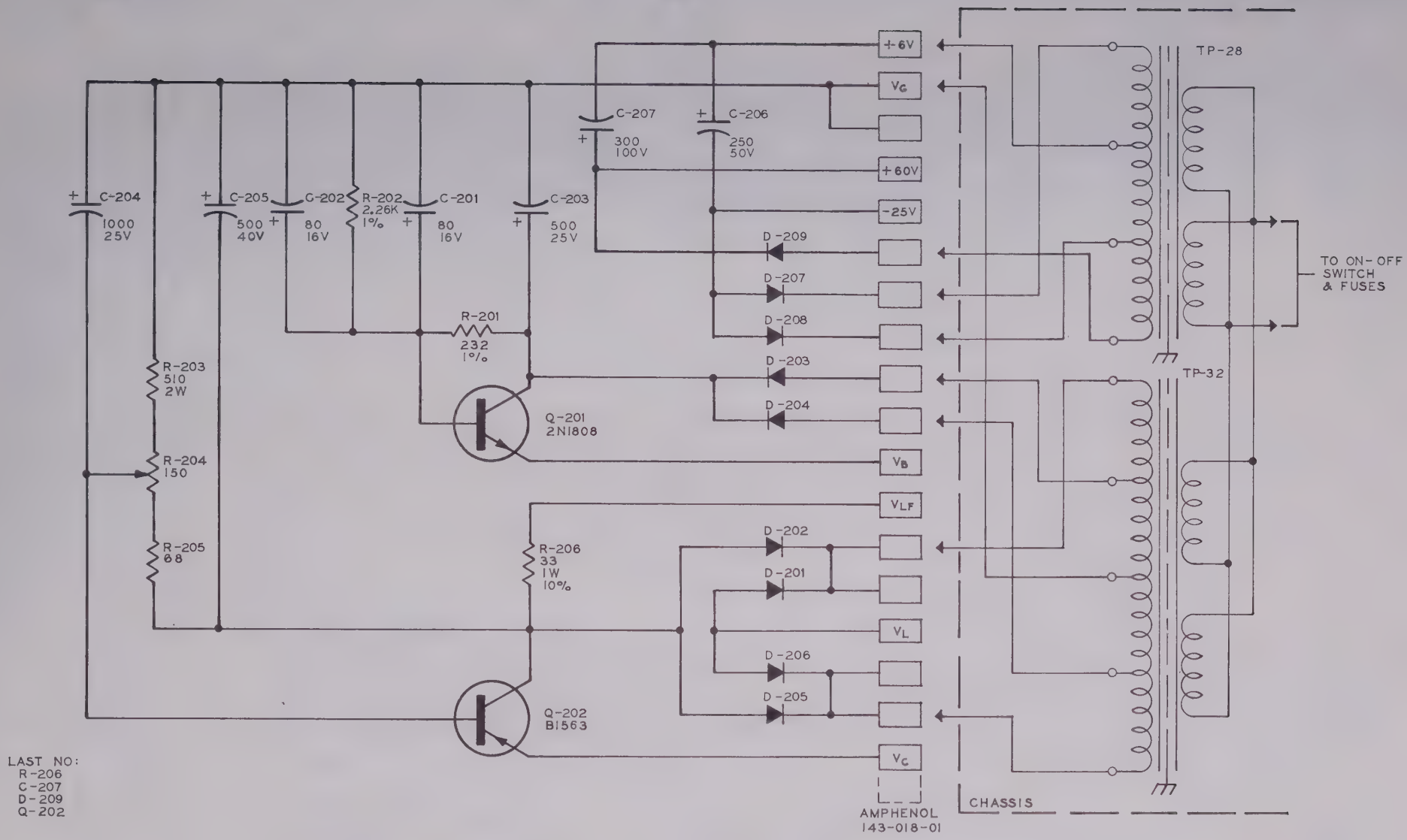


Fig. 5 - Counter



LAST NO:
R-206
C-207
D-209
Q-202

NOTES:
1. ALL CAPACITORS ARE IN MFD.
2. D-201 THRU D-208 — D-S1-50
3. D-209 — D-360

Fig. 6 — Power Supply

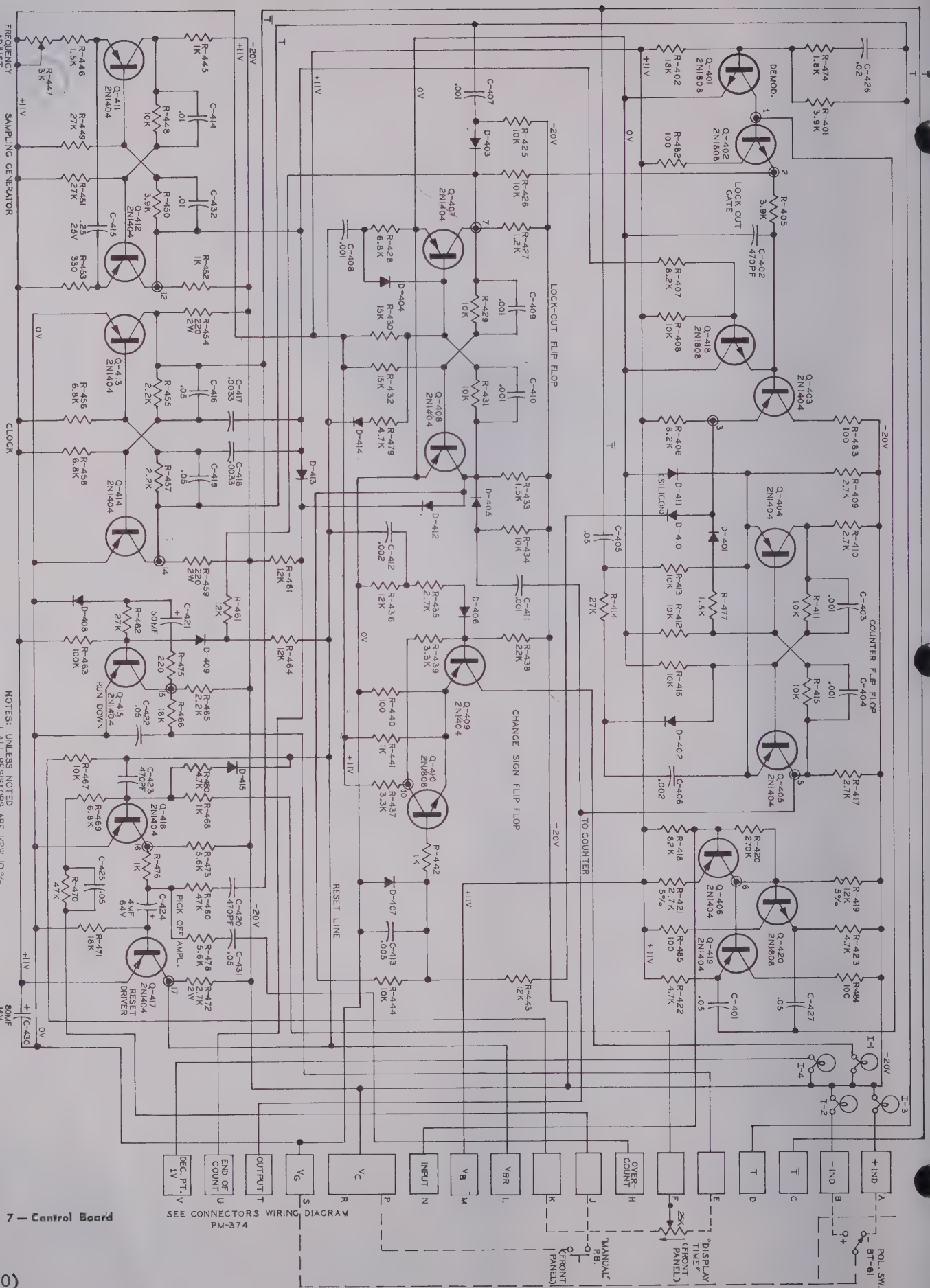


Fig. 7 — Control Board

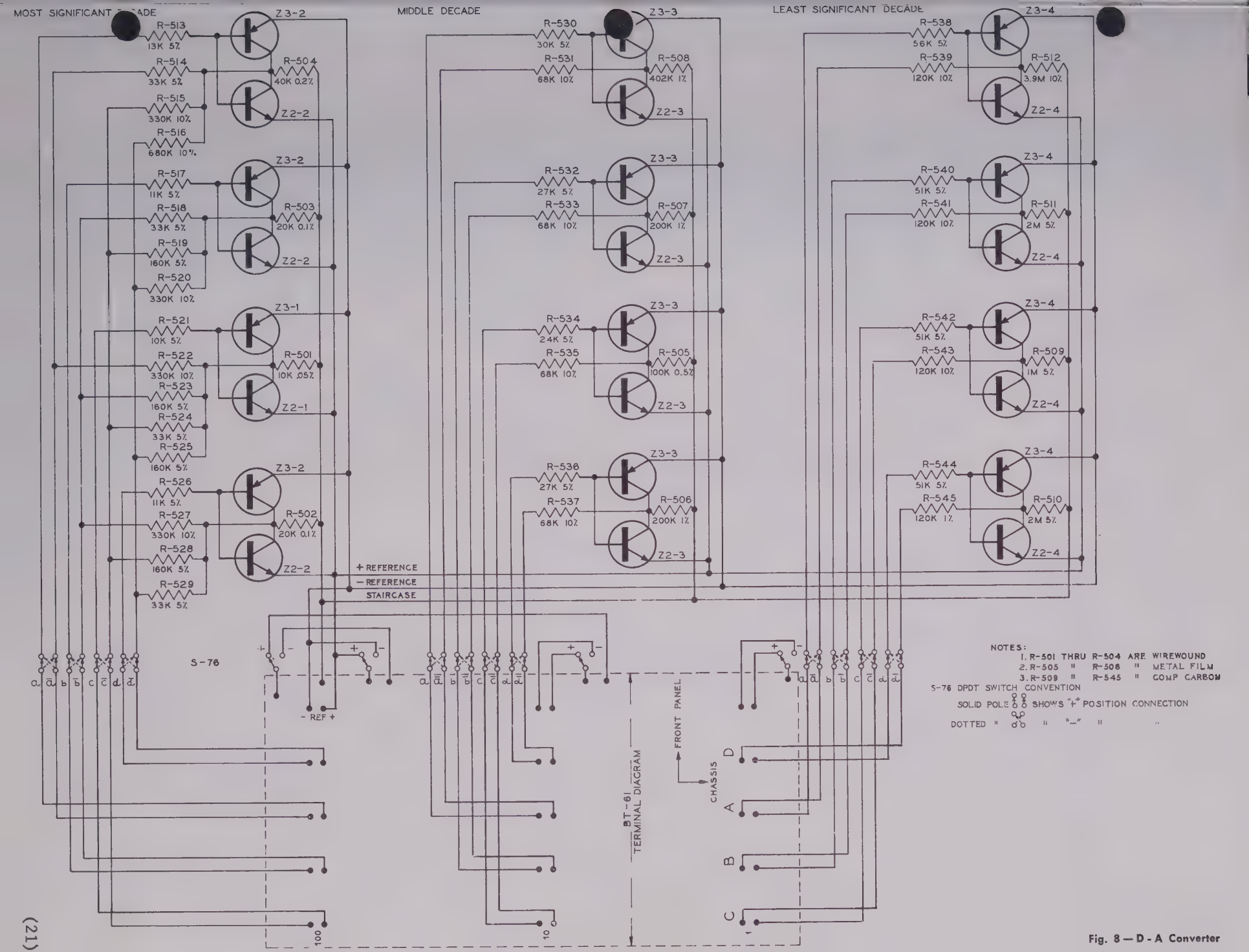


Fig. 8 — D - A Converter

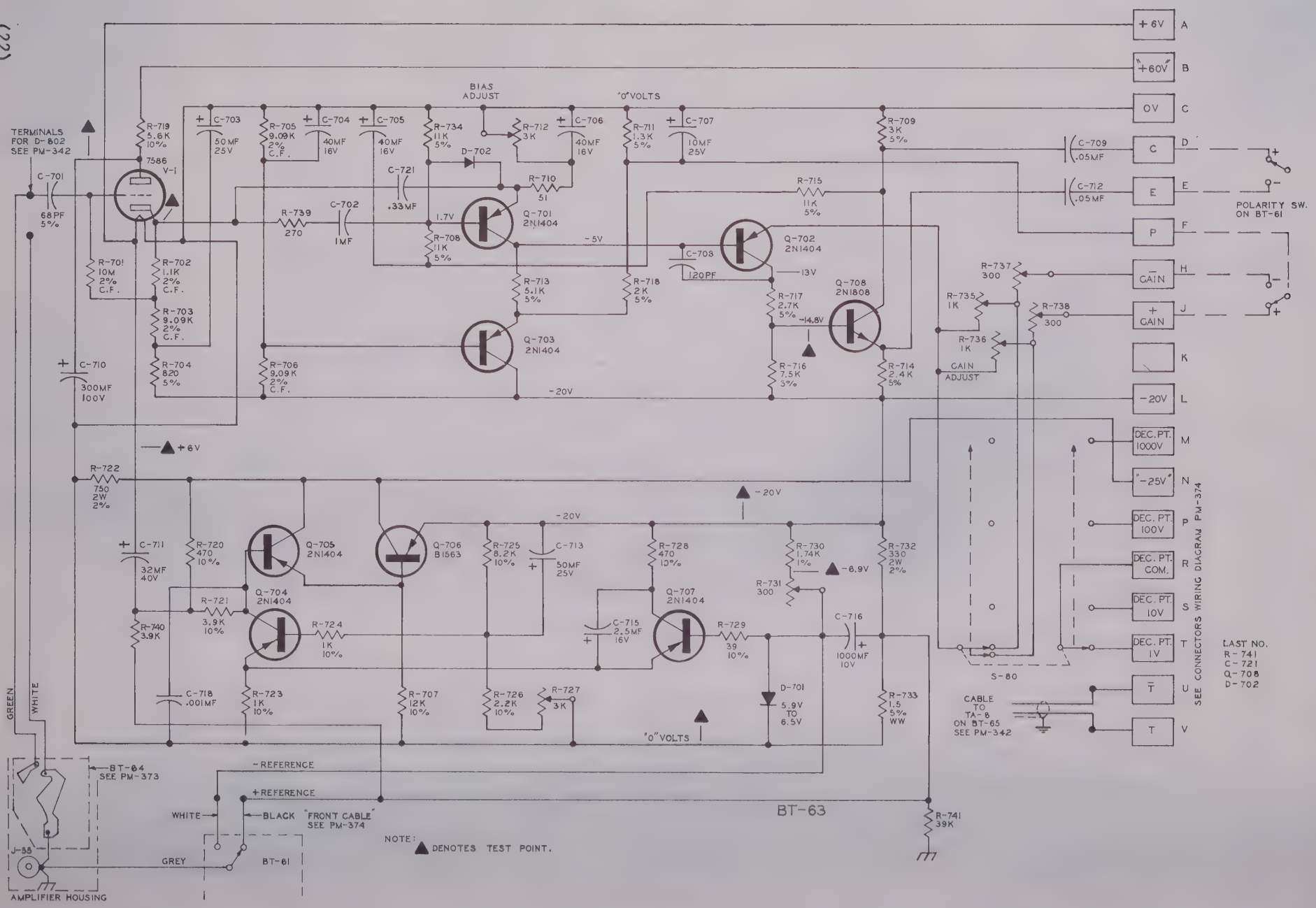


Fig. 9 — Amplifier

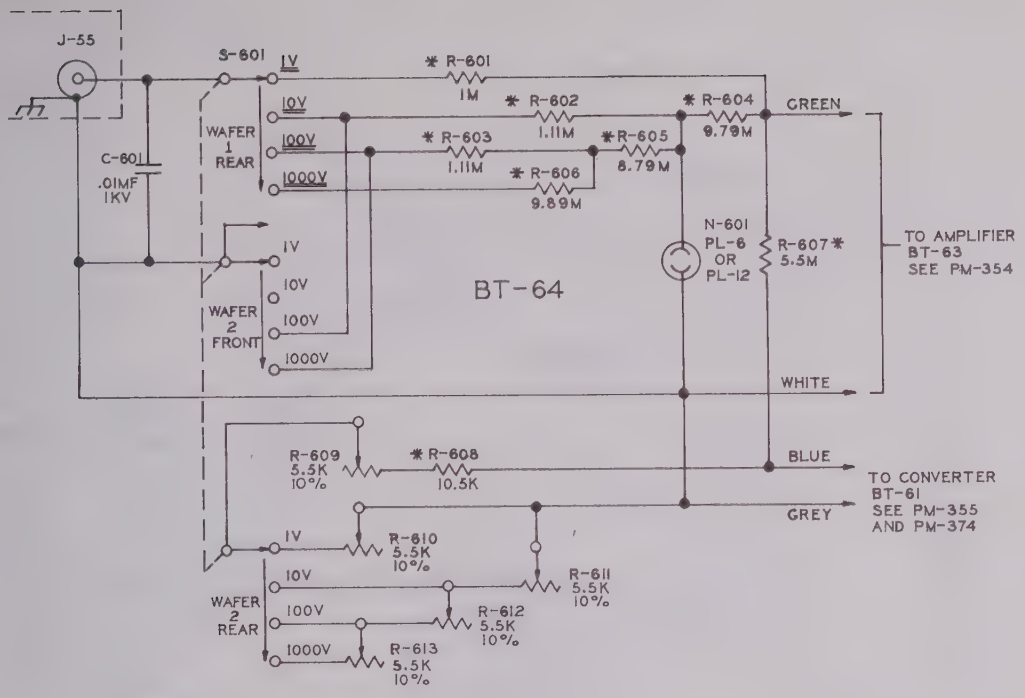


Fig. 10 — Attenuator

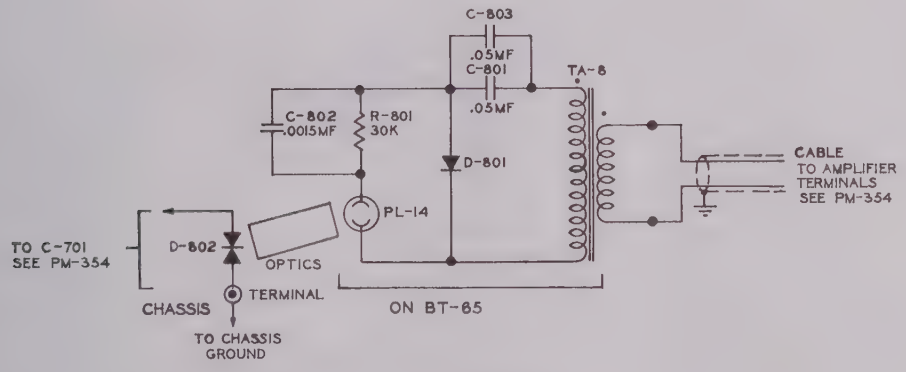


Fig. 11 — Chopper

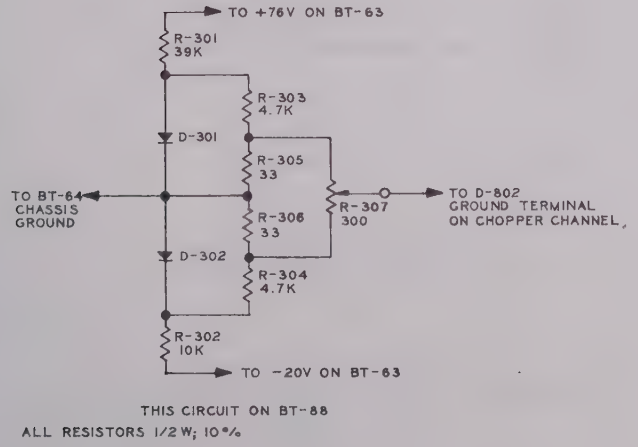


Fig. 12 — Offset Adjustment

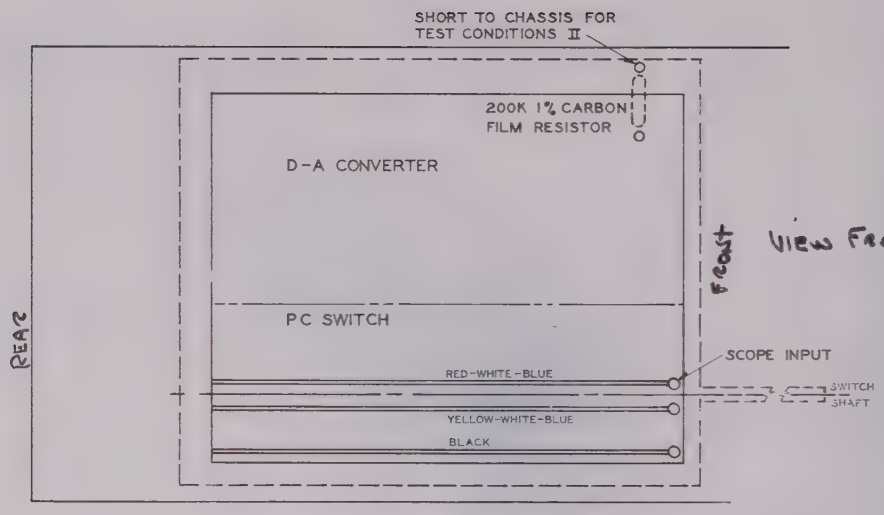


Fig. 13 — Scope Connection

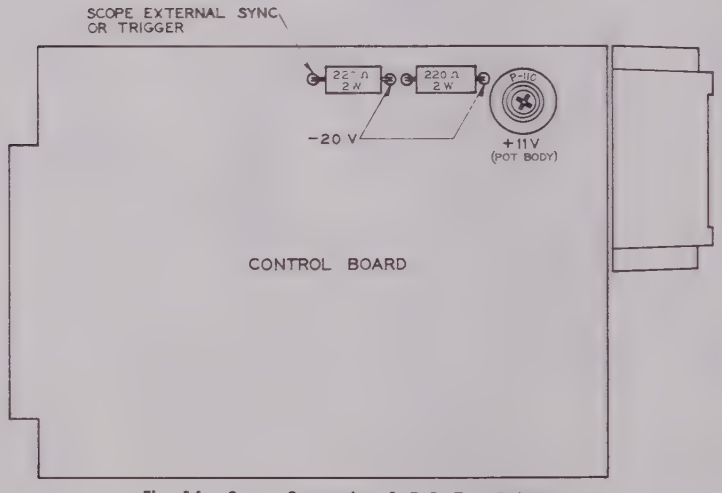


Fig. 14 — Scope Connection & D.C. Test Points

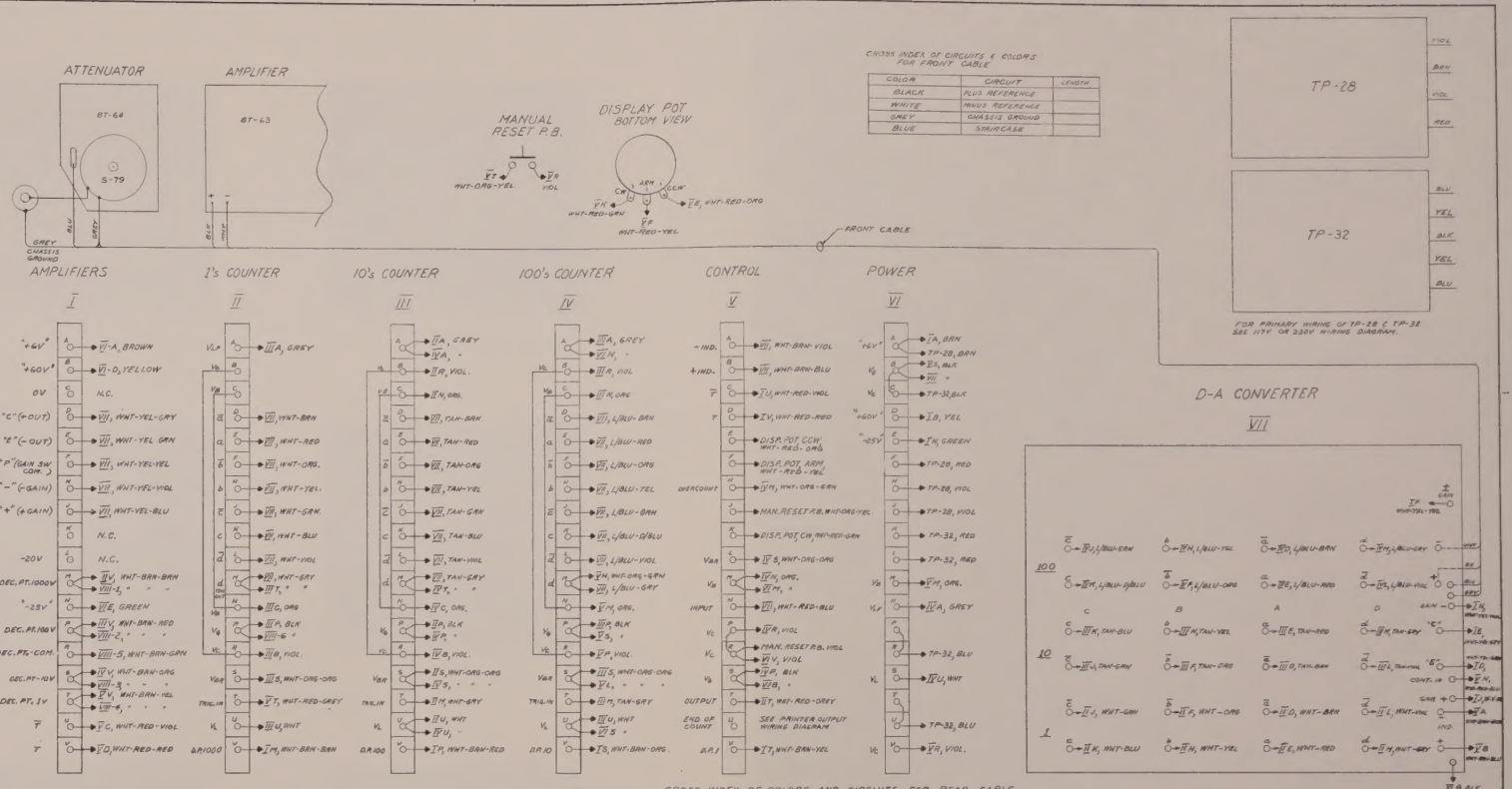


Fig. 17 — Connector Wiring Diagram

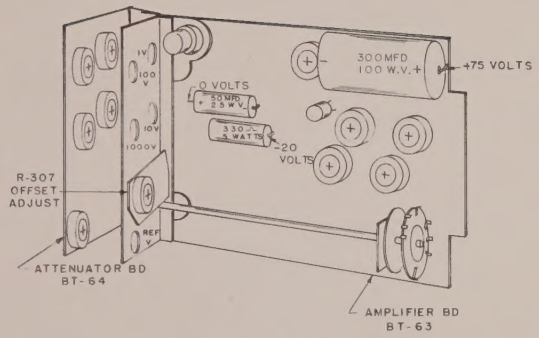


Fig. 15 — Calibration Adjustments

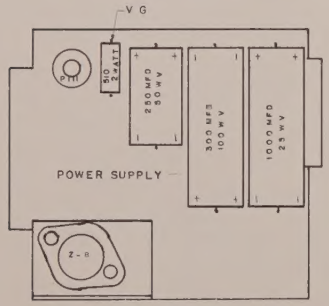


Fig. 16 — VG Test Point

Figure 17 is under this flap

Figures 18, 19, 20 and 21 follow on page 28

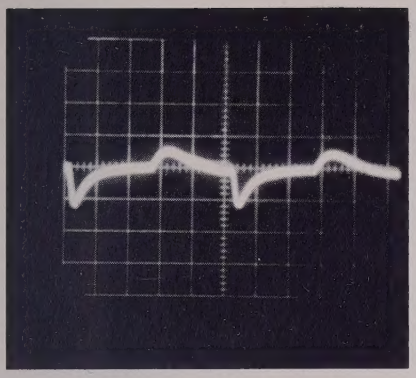


Fig. 18 — Typical Signal Polarity Switch, Positive

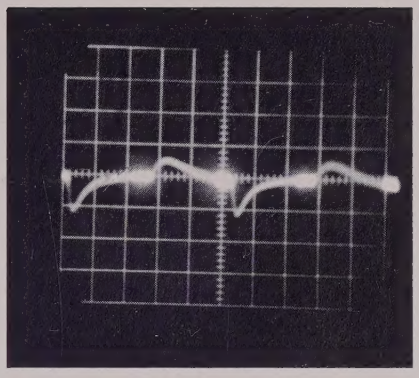
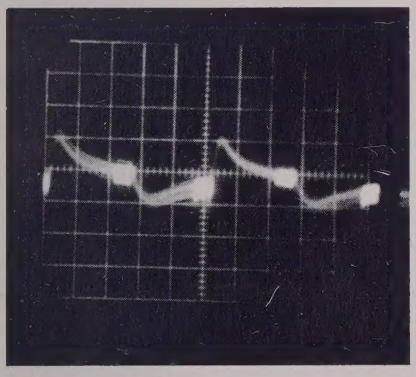
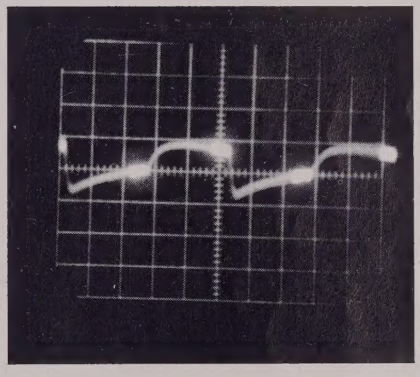


Fig. 19 — Comparison Points of Signal Waveform Polarity Switch, Positive

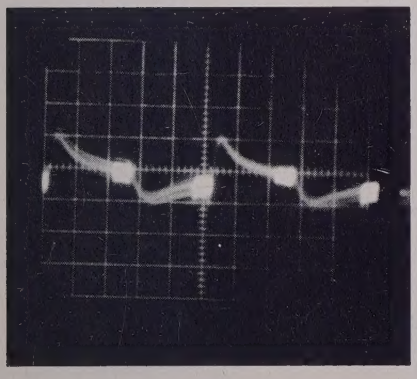


(a) Polarity Switch Negative

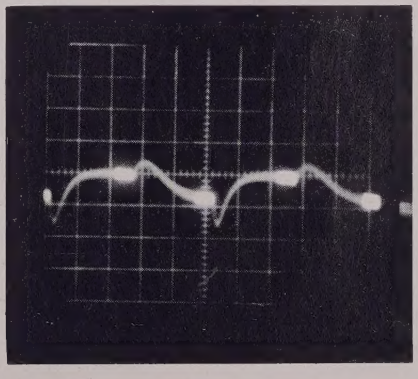


(b) Polarity Switch Positive

Fig. 20 — An Offset which can be reduced by adjustment of R-307



(a) Polarity Switch Negative



(b) Polarity Switch Positive

Fig. 21 — An Unbalance which can be reduced by adjustment of appropriate calibration potentiometer

All Waveforms are with Oscilloscope sweep rate of 0.2 millisec per division and Vertical Gain set to 0.2 volts per division.

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